

Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

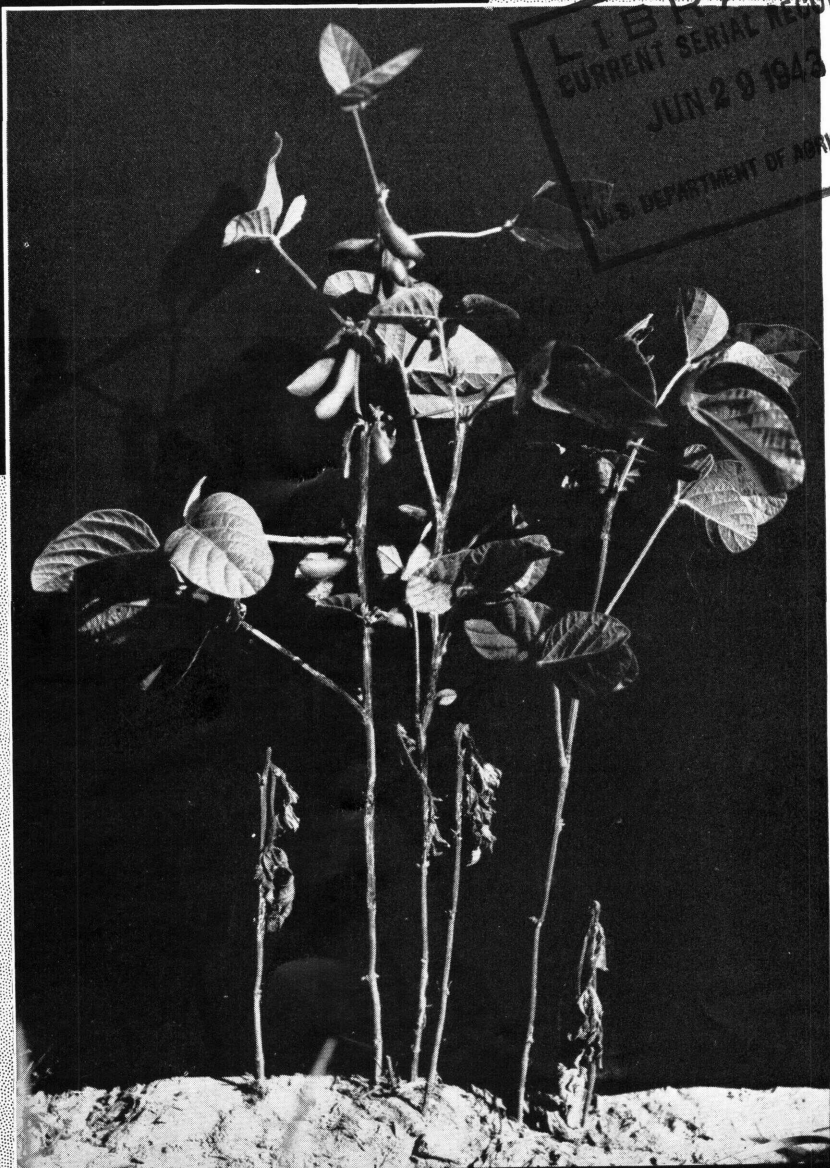
984F Co. 4

SOYBEAN DISEASES

AND THEIR CONTROL

FARMERS'
BULLETIN
No. 1937

LIBRARY
CURRENT SERIAL RECORD
JUN 29 1943
U.S. DEPARTMENT OF AGRICULTURE



U.S. DEPARTMENT OF AGRICULTURE

	Page
LEAF, STEM, POD, AND SEED DISEASES	
<i>Bacterial blight</i> and <i>bacterial pustule</i> .—Probably most conspicuous and widespread soybean diseases in the United States.....	1, 2
<i>Pod and stem blight</i> .—Increasing in prevalence in the Corn Belt States; distinct menace to production in that region.....	4
<i>Frog-eye, brown spot, and anthracnose</i> .—Cause spotting of leaves, stems, and pods, particularly in the Southeastern States.....	5, 7
<i>Downy mildew</i> .—Widely distributed foliage disease; recently found on seeds also.....	7
<i>Powdery mildew</i> .—White, powdery growth on the leaves; not of economic importance in the United States at present.....	10
<i>Alternaria leaf spot</i> .—Common in some sections of the Corn Belt States as large brown spots with concentric rings.....	10
<i>Arsenical injury</i> .—Similar in appearance to <i>Alternaria</i> leaf spot.....	11
<i>Mosaic</i> .—Occurs wherever crop is grown; appears to be distinct threat to production.....	12
<i>Mineral deficiencies</i> .—Cause a chlorosis similar to that caused by virus infection.....	14
<i>Seed discolorations</i> .—Common in the Corn Belt States in certain years...	15
ROOT AND CROWN DISEASES	
<i>Charcoal rot</i> .—Common in the central Mississippi Valley and may be more widespread.....	17
<i>Sclerotial blight</i> .—Particularly severe in sandy soils of the South where high temperatures prevail.....	17
<i>Stem rot</i> .—Only a minor disease in the major producing areas.....	19
<i>Fusarium blight</i> .—Severe on sandy soils in the South.....	19
<i>Pythium, rhizoctonia, and phymatotrichum root rots</i> .—Cause losses in some regions each year.....	19
<i>Root knot</i> .—Causes severe injury in many parts of the Southern States....	21
<i>Lightning injury</i> .—Plants killed in areas up to 50 feet in diameter.....	21
CONTROL MEASURES	
<i>Disease-resistant varieties</i> .—Recommended to avoid losses from some diseases.....	22
<i>Crop rotation</i> .—Tends to keep losses from diseases at a minimum.....	22
<i>Disease-free seed</i> .—Use to prevent spread of diseases to new localities...	23
<i>Seed treatment</i> .—Frequently improves stand, especially when vitality of seed is not very high.....	23
<i>Exclusion</i> .—Constant vigilance needed to prevent introduction of new diseases into the United States.....	24

SOYBEAN DISEASES AND THEIR CONTROL

By HOWARD W. JOHNSON, senior pathologist, Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, United States Department of Agriculture, and BENJAMIN KOEHLER, chief in crop pathology, Illinois Agricultural Experiment Station.¹

THE SOYBEAN, *Soja max* (L.) Piper, is becoming increasingly important in American agriculture. It is imperative, therefore, that everything possible be done to safeguard the crop against the ravages of diseases. Thus far, as with most crops in the first years of intensive production in a new country, the soybean has been relatively free from serious epidemics of disease, except for the widespread attack in the South by sclerotial, or southern, blight (*Sclerotium rolfsii* Sacc.) and by the root knot, or nematode, disease (*Heterodera marioni* (Cornu) Goodey). However, numerous other diseases of the soybean, which are not so well known, do occur in this country, and these constitute a constant menace to the crop. In the case of certain of the diseases, the causal agent is known to be seed-borne. Failure to give due recognition to the importance of these diseases now can result only in an increase in their prevalence and increasingly severe losses as the seed sources become more and more highly infested. Effective control measures for such diseases need to be devised, and desirable varieties or selections resistant to the more important diseases should be discovered or developed without delay. It is the purpose of this bulletin to bring together the information available on soybean diseases in the United States.

LEAF, STEM, POD, AND SEED DISEASES

BACTERIAL BLIGHT

Bacterial blight has been reported from various parts of the United States and probably is the most conspicuous and common disease of the soybean. Some bacterial blight is usually evident in every field by the time the plants are half-grown, and the disease remains active until the plants mature. If there are periods of high humidity or heavy dews during the summer, severe loss of functional leaf surface and defoliation may occur. The disease is first evident on the leaves as small, angular, yellow spots that soon become light brown and later become dark brown or black (fig. 1). The diseased tissues eventually become quite dry and may drop out, giving the leaves a ragged appearance. Similar spots may occur also on the stems and pods. *Pseudomonas glycinea* (Coerper) Stapp has been reported as causing symptoms of this kind on soybeans. Studies have shown that the

¹ Cooperative investigations by the Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, and the Illinois Agricultural Experiment Station, Urbana, Ill.

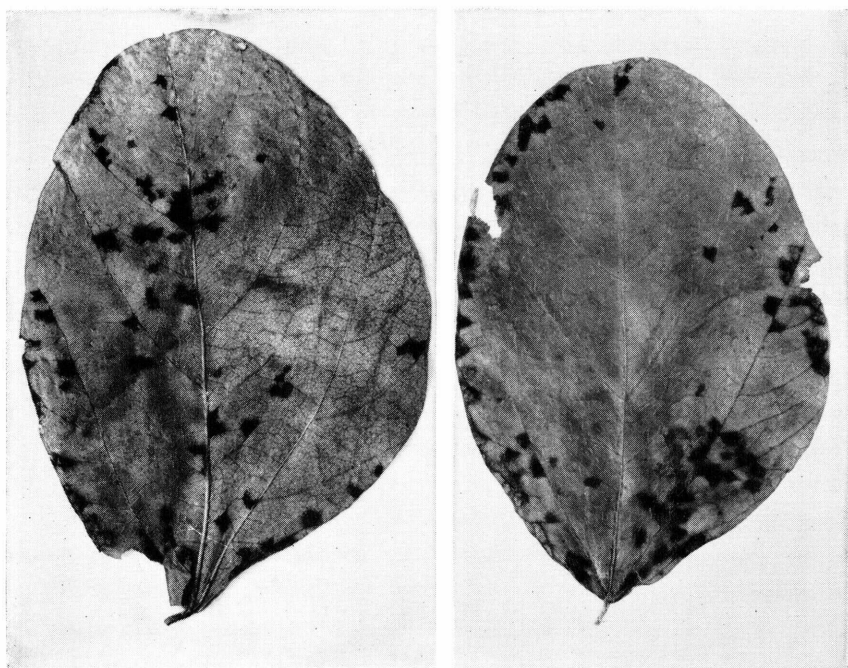


FIGURE 1.—Leaflets of Arksoy variety of soybeans, showing the angular, dark-colored spots that characterize bacterial blight disease.

bacteria are seed-borne and can survive also in dead leaves from one growing season to the next. Reports in the literature indicate that soybean varieties vary greatly in their relative susceptibility to bacterial blight.

BACTERIAL PUSTULE

The symptoms of bacterial pustule are similar to those of bacterial blight, and it is not always easy to differentiate the two in field plantings unless distinct bacterial pustules are present on the lesions. In its later stages bacterial pustule is characterized by angular, reddish-brown spots on the leaves, which range in size from small specks to large, irregular, brown areas that are surrounded often by yellow margins. Frequently portions of the larger spots drop out, giving the leaves a ragged appearance, as shown in figure 2. The disease is caused by *Xanthomonas phaseoli* var. *sojense* (Hedges) Starr and Burkholder, an organism quite distinct from that which causes bacterial blight. Although the disease is confined chiefly to the foliage, the bacteria may also infect and spot the pods. The bacteria apparently overwinter in the fallen, diseased leaves and perpetuate the disease in this way.

The Oklahoma Agricultural Experiment Station has reported that from a total of 30 varieties and selections of field soybeans only the variety Chief and selections Arksoy 152 and C-146 were relatively free of the bacterial pustule disease. In another varietal test at this station in which locally obtained seed of 23 varieties of field soybeans was used, only 3 varieties (Habaro, Ogden, and Scioto) appeared to be

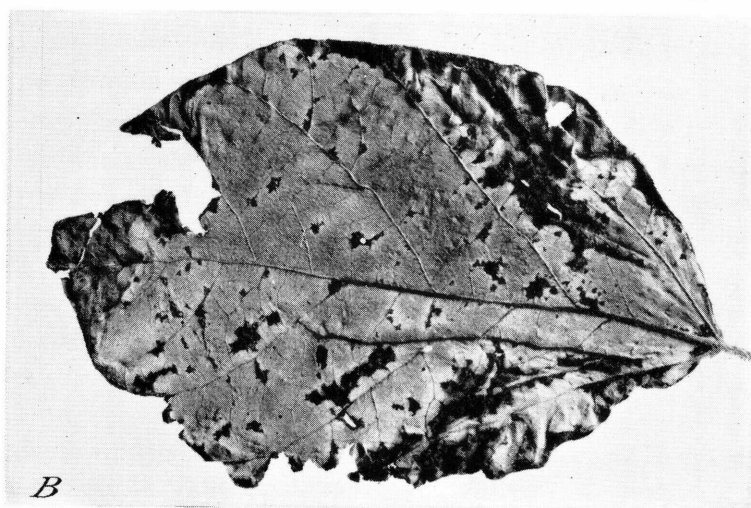
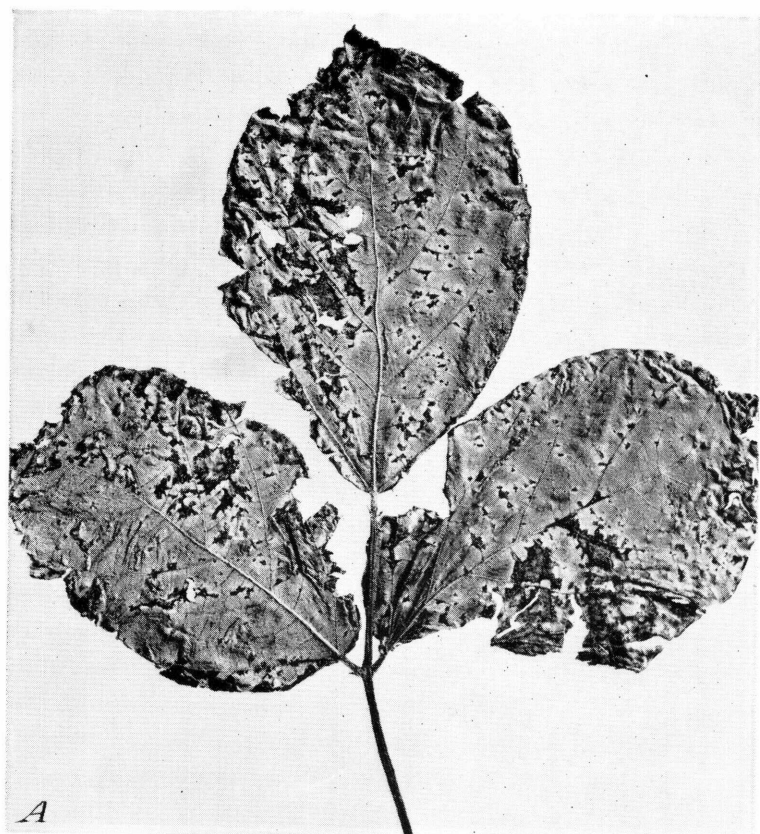


FIGURE 2.—*A*, Bacterial pustule disease on a soybean leaf;
B, enlarged leaflet.



FIGURE 3.—Pod and stem blight infection that started at the junction of a branch with the main stem. The branch and an area of the main stem were killed when the seeds were about half-grown.

relatively free of the disease. None of the 27 varieties and selections of edible soybeans grown at this station seemed to be resistant to bacterial pustule. Further tests of the susceptibility of the newer varieties and selections are needed in different localities, since the disease is prevalent in various parts of the United States.

POD AND STEM BLIGHT

Pod and stem blight, a fungus disease caused by *Diaporthe sojae* Lehm., was observed for the first time in North Carolina in 1920. It has recently become established in the Corn Belt and now constitutes a distinct menace to soybean production in that region. Fields

with a high percentage of the plants dead from stem blight have been observed in Indiana and Illinois. The disease has also been reported as injurious in Iowa.

Infection usually starts at the junction of a branch or petiole with the stem, most often near the base but sometimes at a foot or two above the ground (fig. 3). The fungus girdles the stems, thus killing the plants prematurely and preventing the young seed from developing. Pods are attacked quite commonly also, but leaves are seldom attacked.

Numerous black pycnidia of the fungus are usually found scattered over the diseased plant parts, as shown in figure 4, and serve as a distinctive marker of the disease. Relatively high humidity is conducive to the production and spread of microscopic spores from the black fruiting bodies of the fungus, and losses will usually be greater in rainy seasons than in dry ones. In 1926, with a September rainfall of about three and one-half times normal in Illinois, much of the soybean seed carried internal infection with *Diaporthe sojae* and failed to germinate. The fungus overwinters on the dead stems and in in-

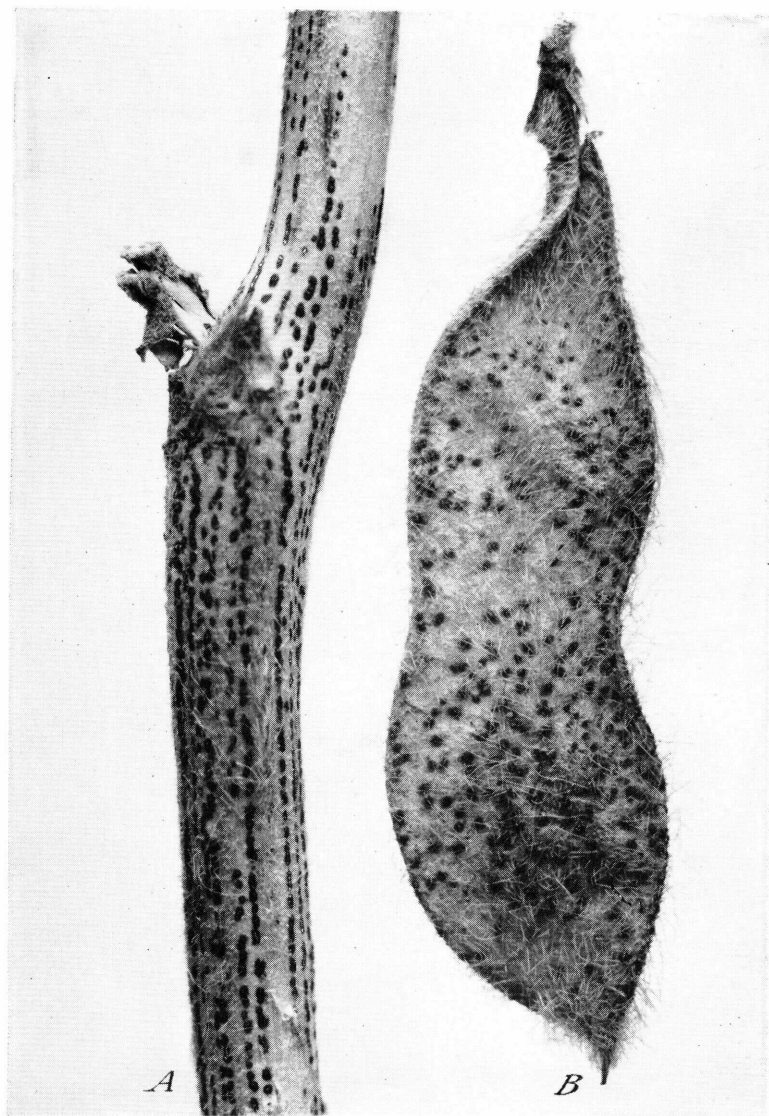


FIGURE 4.—A. Enlarged view of the pycnidia of the pod and stem blight fungus on a soybean stem; B, pod.

fectured seed, thus providing for the perpetuation of the disease. Therefore, sanitation, the use of disease-free seed, and crop rotation are recommended as control measures. Little is known about the relative susceptibility and resistance of soybean varieties to this disease.

FROG-EYE DISEASE

The frog-eye disease was first found in Manchuria in 1918 and was reported from the southern United States in 1926. The causal fungus is *Cercospora diazu* Miura. The disease is characterized by the typical

"frog-eye" spotting of the leaves illustrated in figure 5. Heavily spotted leaves usually fall prematurely, thus causing the loss to the hay and seed crops. Stem infections are less numerous and somewhat less conspicuous than those on the leaves and appear in the field in large numbers only in late fall, when the plants are maturing seed. Stem lesions are elongated and are some shade of red when young but become brown, then smoke-gray or almost black with age. Pod infections also occur on late-maturing varieties of soybeans, and the fungus frequently goes through the pod and closely invests the seed. According to reports from the North Carolina Agricultural Experiment Station, however, the fungus apparently enters the seed-coat tissues of relatively few seeds, as it can usually be killed by seed disinfectants.

The fungus overwinters on diseased leaves and stems and apparently is introduced into new fields and new communities through the planting of infected seed. Thus far seed treatment has failed to give satisfactory control of the disease in field tests. Reports from North Carolina indicate that early-maturing varieties, such as Dixie, Manchú, and Virginia, escape serious injury, but such late-maturing varieties as Ootootan and Biloxi may be seriously injured. However, a large field of Virginia soybeans in Carroll County, Md., has been reported to have been heavily infected with frog-eye leaf spot disease.

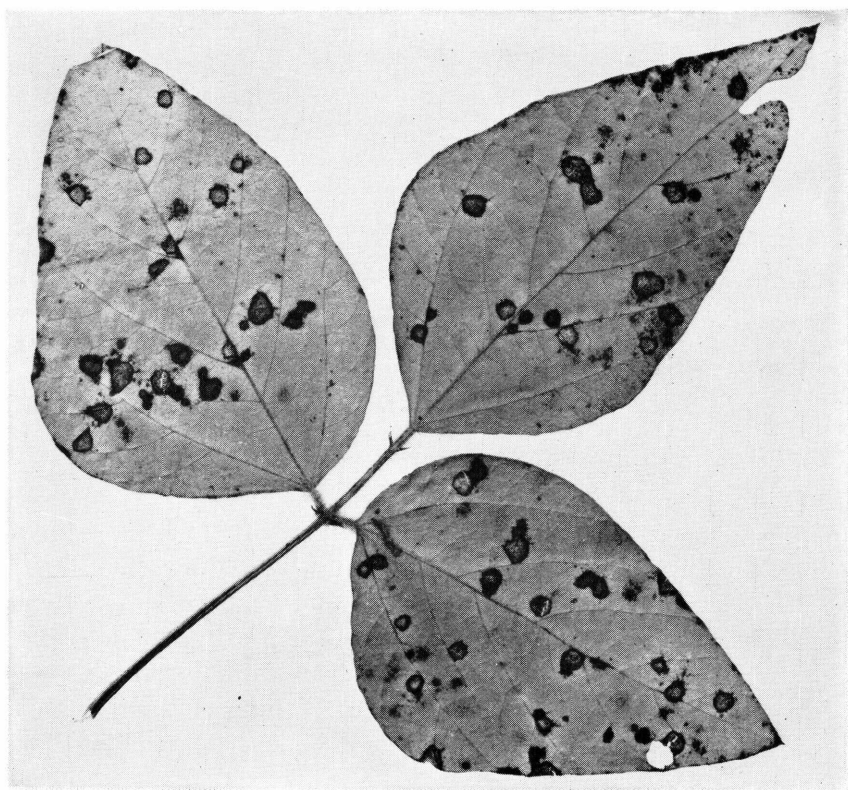


FIGURE 5.—Frog-eye disease on a soybean leaf.

BROWN SPOT

Brown spot disease is characterized by the presence of angular brown or reddish-brown lesions on the foliage. Heavily spotted leaves become chlorotic and fall off, defoliation proceeding from the base toward the top of the plant. Spotting also develops on the stems and pods as the plants approach maturity. On these plant organs the lesions vary from tiny specks to areas several centimeters in length. Investigations at the North Carolina Agricultural Experiment Station showed that the causal fungus *Septoria glycines* Hemmi probably is seed-borne, and these results suggest that contaminated seeds are the agency by which it is disseminated. These studies also showed that the conidia of the fungus were able to survive the winter on diseased leaves and stems. Refuse from a diseased crop could therefore be expected to serve as a source of inoculum when the same field is returned to soybeans the following year. One season's observations on varietal resistance under North Carolina conditions showed the following varieties to be only slightly affected: Mammoth Yellow, Haberlandt 38,² Laredo, Biloxi, Lexington, Tokyo, Tarheel Black, and Chiquita.

ANTHRACNOSE

Anthracnose affects the stem and pods and is characterized by the presence of numerous black fruiting dots (acervuli) uniformly scattered over the surface of the affected parts. (See fig. 6.) The symptoms are similar to the pod and stem blight disease discussed on page 4, but the anthracnose fruiting bodies are irregularly scattered over the surface of the affected stems, whereas those of the pod and stem blight fungus are usually arranged in straight lines, as shown in figure 4, A. A further difference that will assist in differentiating these two diseases is the spiny nature of the anthracnose fruiting bodies, as shown in figure 6, A. These tiny spines, or setae, can be seen readily under hand-lens magnification and are important to observe for diagnostic purposes. The diseased plants die prematurely, and the pods do not fill properly. The causal fungus, *Glomerella glycines* (Hori) Lehm. and Wolf, is seed-borne and exists as mycelium within the seed and as spores adhering to the exterior. If infected seed is planted, it germinates poorly and the stand is reduced.

The disease, known in the Orient since 1917, was reported from North Carolina in 1920 and was also observed to be causing considerable injury to soybeans in field tests at Quincy, Fla., during the summer of 1937. More recently anthracnose was reported as injurious to soybeans in Illinois and Iowa. The fungus passes the winter season by means of infected seed and by means of the perithecial stage that develops on diseased stems left in the field over winter. Control measures recommended for pod and stem blight would seem applicable.

DOWNY MILDEW

The downy mildew disease is widely distributed in the United States, but serious epidemics have not been reported from any locality. It is characterized in early stages by indefinite chlorotic areas on the

² Now known as the Herman variety.

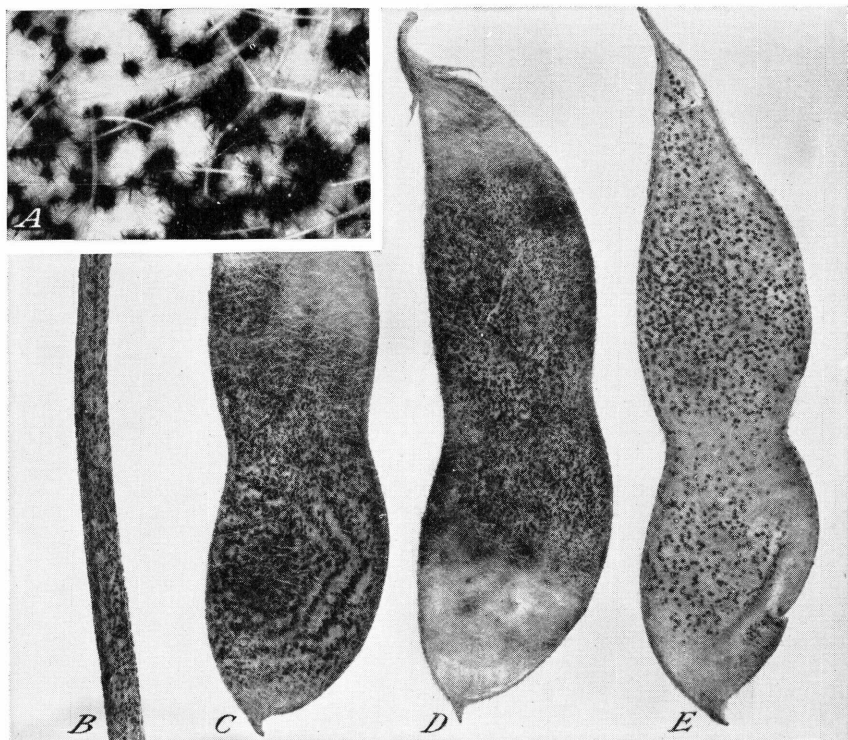


FIGURE 6.—A, Fruiting bodies of the soybean anthracnose fungus enlarged about 25 times to show their spiny nature; B, as they appear in nature on a small stem; and C and D, on pods of the Higon soybean. Compare with the pycnidia of the pod and stem blight fungus (E).

upper side of the leaves (fig. 7, A). As the causal fungus, *Peronospora manshurica* (Naoum.) Syd., progresses through the leaf tissues these areas change to well-defined grayish-brown to dark-brown lesions surrounded by chlorotic margins (fig. 7, B and C). Grayish-colored masses of conidiophores are present on the under surface of the lesions in most cases (fig. 8). The spores produced on the conidiophores are responsible for the spread of the disease from plant to plant during the growing season. In addition to these asexual summer spores, thick-walled resting spores develop within the leaf tissues as a result of sexual fusion. These are called oospores and are the form in which the fungus passes the winter season.

For many years this disease was thought to be confined to the foliage, but it has been discovered recently that the fungus also attacks the seed. Seeds of the 1941 crop of the Mammoth Yellow variety having cracked seed coats covered with a whitish crust were examined, and the milky-appearing crust was found to be an almost solid mass of downy mildew oospores (fig. 9). In addition to the injury to the seed thus caused, it is probable that seed-borne oospores are the means by which the fungus is introduced into new field.

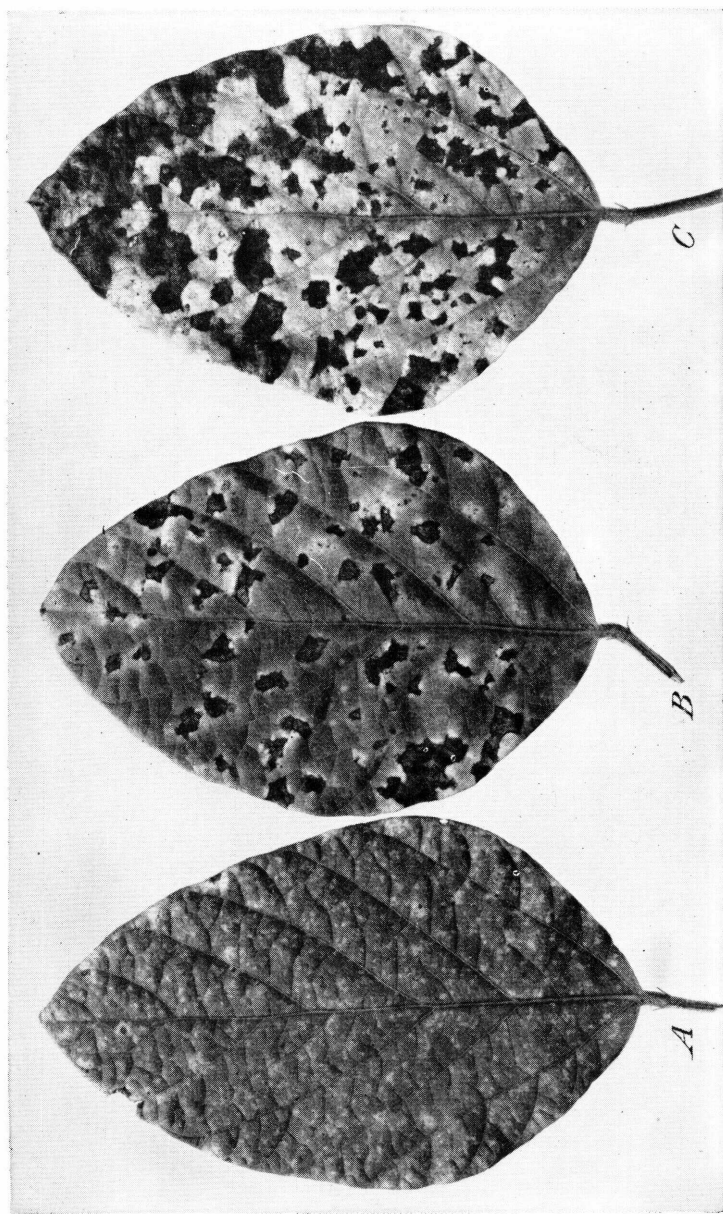


FIGURE 7.—Upper surface of soybean leaflets, showing progressive stages of the downy mildew disease: *A*, Indefinite chlorotic areas; *B*, dark-brown lesions with chlorotic margins; *C*, more extensive lesions with general chlorosis.

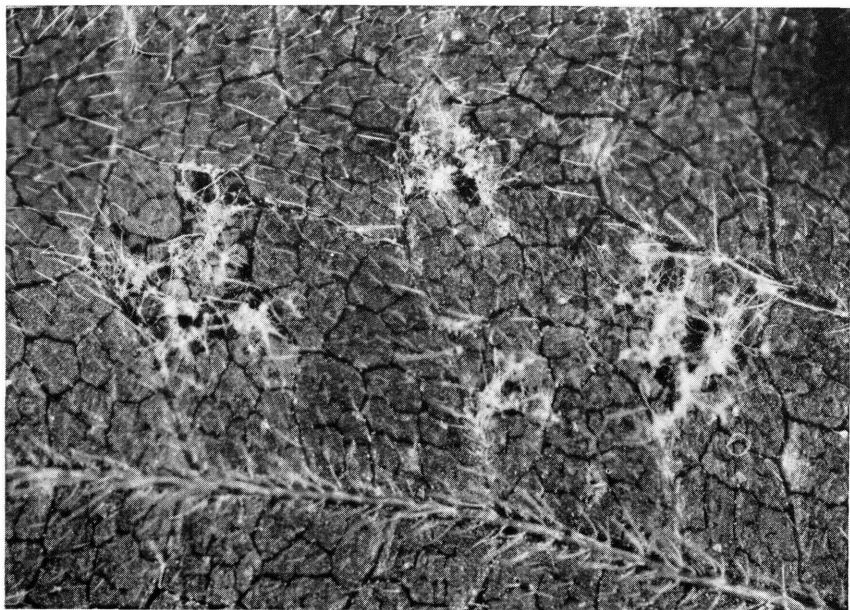


FIGURE 8.—Undersurface of a soybean leaflet enlarged to show the grayish-colored masses of conidiophores of the downy mildew fungus.

POWDERY MILDEW

The powdery mildew disease of soybeans is characterized by a white, powdery growth on the leaves. It has been observed in the greenhouse at Raleigh, N. C., and has been reported once on field-grown soybeans in this country. It has been reported from Europe, where the parasite was identified as *Erysiphe polygoni* DC. Although no perithecia have been observed on soybeans in this country, it is considered probable that the fungus here is the same as the powdery mildew of soybeans in Europe. At the present this disease is not of economic importance on soybeans, but it should be kept under observation because it may at some time assume epidemic proportions, as did the powdery mildew of red clover in 1922.

ALTERNARIA LEAF SPOT

Relatively large brown spots with characteristic concentric rings have been observed on soybean leaves in Indiana and Illinois during recent years (fig. 10). Isolations from such spots have yielded a species of *Alternaria*, and artificial inoculations made at Urbana, Ill., have proved the ability of this fungus to cause the typical leaf spots. The specific identity of the fungus has not yet been determined.

An investigation of the cause of small, brick-red spots on soybean leaves, made at the Arizona Agricultural Experiment Station, showed that the primary cause was sunburning of the leaves or aphid injury. These spots later enlarged, sometimes coalescing, became brown, and sometimes were covered with a sooty-black fungal growth. The fungus was considered to be a secondary invader that was weakly parasitic on soybeans and was described as a new species, *Alternaria atrans* Gibson. Whether this species of *Alternaria* has any relationship to the disease observed in Indiana and Illinois is not known.



FIGURE 9.—Seeds of the Mammoth Yellow variety of soybeans enlarged to show the cracked seed coats and milky-appearing crust of downy mildew oospores.

ARSENICAL INJURY

Spotting of soybean leaves quite similar to the *alternaria* leaf spot just described has been observed in Illinois to develop after poison bait had been scattered over the plants to kill grasshoppers (fig. 11). The concentric rings on the spots could lead readily to confusion with the similar-appearing fungus leaf spot. However, the spots due to arsenical injury remain free of mold growth until late in the season, when *Alternaria* is observed commonly to have overgrown them. Although this injury is probably not of economic importance on soybeans.

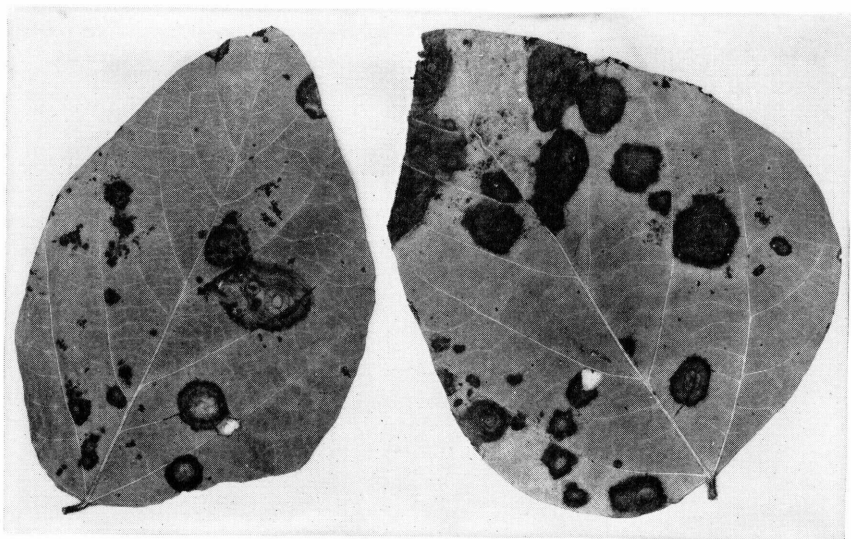


FIGURE 10.—*Alternaria* leaf spot on soybean leaflets.

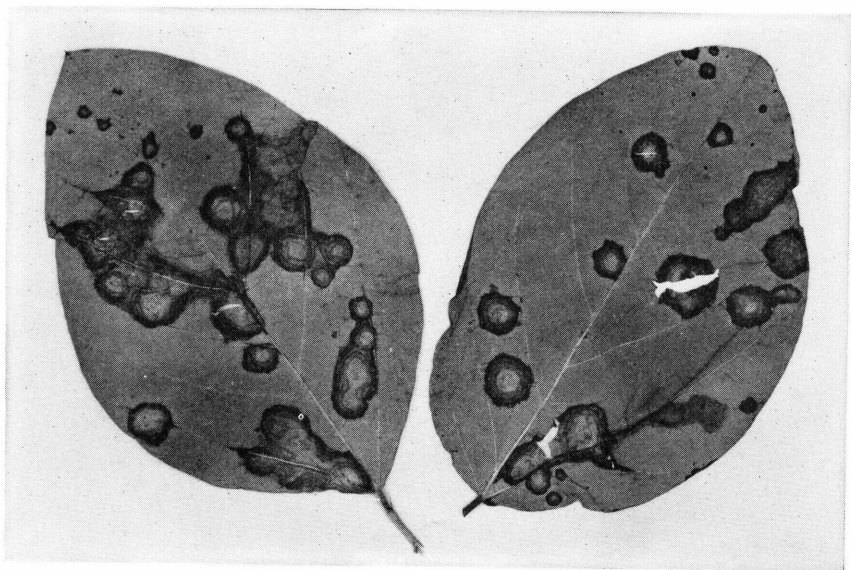


FIGURE 11.—Spotting of soybean leaflets caused by arsenical poison bait scattered over plants to kill grasshoppers.

it appears desirable to call attention here to the sensitiveness of the soybean foliage to arsenical injury.

MOSAIC

Mosaic, a virus disease, was reported from Connecticut in 1916 under the name of chlorosis, or crinkling, and now appears to be common in all the major soybean-growing areas. The symptoms are a misshapening of the leaves with dark-green puckers along the

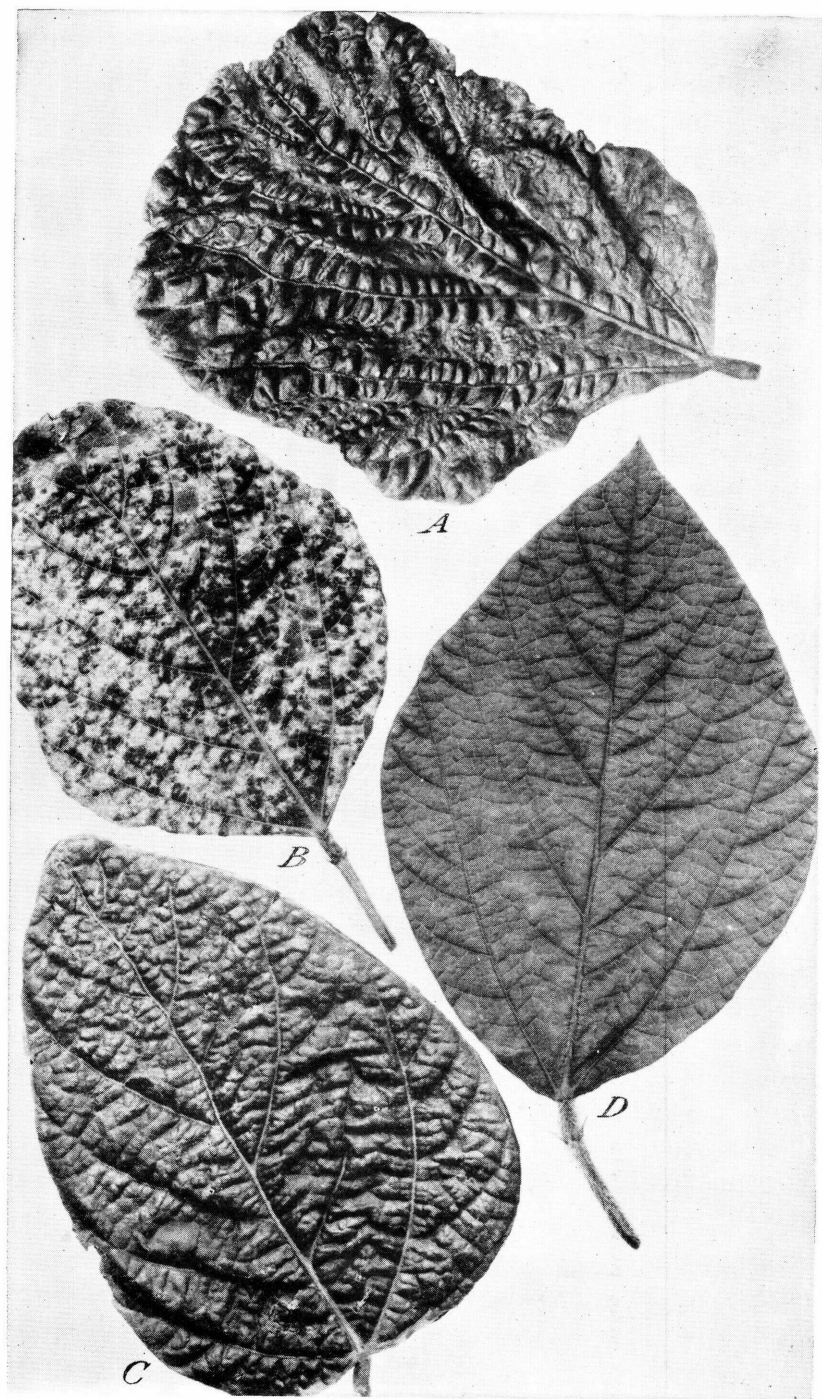


FIGURE 12.—Mosaic symptoms on soybean leaflets (*A*, *B*, and *C*) and a healthy leaflet (*D*).

veins or over the entire leaflets (fig. 12, *A*). Plants affected with mosaic are stunted in growth, the pods are stunted and flattened, and the yield of seed is materially reduced. Studies have shown that the disease is seed-borne and that it is transmissible from plant to plant. Studies at the Indiana Agricultural Experiment Station showed that varieties differ widely in susceptibility, the Midwest, Haberlandt, and Black Eyebrow varieties appearing to be most susceptible. Certain of the newly introduced green vegetable varieties of soybeans also are very susceptible to mosaic, and this disease appears to be a factor in their production.

In addition to these typical mosaic symptoms, the leaves in some cases remain smooth, but the surface becomes sharply mottled in angular designs (fig. 12, *B*). In other cases the leaf surface becomes crinkled or wrinkled in a characteristic fashion (fig. 12, *C*) quite different from the puckering observed in the mosaic described first (fig. 12, *A*). Such leaves are dark green throughout, and sometimes there is a noticeable stunting resulting from shortened internodes and petioles. Delayed maturity apparently results from this kind of virus infection, the mosaic plants remaining green longer than the healthy plants. This variety of symptoms suggests that there are several virus diseases of soybeans rather than one. Also, it is probable that different varieties produce somewhat different symptoms, and it is known that some insect injuries result in wrinkling or puckering of the leaves. Under some conditions potash deficiency is reported to cause crinkling and mottling of soybean leaves. Further research is needed to gain a better understanding of the mosaic problem in soybeans.

MINERAL DEFICIENCIES ³

In addition to being a symptom of virus infection, chlorosis in soybeans may be caused by a deficiency of mineral nutrients. Irregular yellow mottling around the edges of the leaflets is the first sign of insufficient potash. The chlorotic areas soon merge to form a continuous yellow border around the leaflets, and this is followed by marginal firing. The dead tissue usually falls out, giving the leaflets a ragged appearance. The firing may spread to include half or more of the area of the leaflet, leaving only the center and base green in color.

In iron-deficiency chlorosis, large areas between the veins become yellowish green and then yellow. The entire leaflet, including the veins and midrib, finally becomes involved as the chlorophyll disappears.

Nitrogen deficiency is characterized by a gradual paling of the green color over the whole leaf blade with only a slight yellowish tinge. Nitrogen deficiency formerly was seen when noninoculated soybeans were sown, but is not common now because of the general practice of inoculating with the soybean root-nodule bacteria. Iron deficiency

³ For a more detailed discussion of this topic see DE TURK, E. E. PLANT-NUTRIENT DEFICIENCY SYMPTOMS IN LEGUMES. (In Hambridge, G., et al., *Hunger Signs in Crops*, pp. 241-258, illus. Washington, D. C. [1941.])

occurs in certain restricted areas, but the chlorosis and firing due to potash deficiency are encountered frequently in a number of States east of the Great Plains.

SEED DISCOLORATIONS

Purple blotching of soybean seeds has been observed in various sections of the United States and has been considered by some as a nonparasitic trouble probably caused by certain weather conditions prevailing as the seeds mature. A similar spotting of soybean seeds in the Orient has been ascribed to fungus infection, and the causal agent has been described as *Cercosporina kikuchii* Mats. and Tomo. The Indiana Agricultural Experiment Station in 1926 and 1928 reported this fungus as the cause of the purple seed stain observed on seeds of a number of soybean varieties in that State and called attention to the objectionable nature of this discoloration from the standpoint of the producer of pure seed.

In Illinois in 1941 as many as 10 percent of the seeds in a number of soybean varieties showed purple discoloration, whereas numerous other seeds showed a dull-brown discoloration. Figure 13 shows healthy appearing seeds of the Illini variety (*A*) compared with purple-blotched seeds (*B*) and brown-discolored seeds (*C*). Isolations made at the Illinois Agricultural Experiment Station from soybean seeds of each of the three types illustrated in figure 13 gave the results summarized in table 1.

TABLE 1.—Organisms isolated from 4 samples of soybean seeds in Illinois in 1941¹

Variety	Germination	Class No. ²	Seeds yielding various organisms						
			Sterile	Alternaria	Fusarium	Dia-por-the	Non-sporu-lating fungus ³	Bac-teria	Not identi-fied
	Percent		Percent	Percent	Percent	Percent	Percent	Percent	Percent
Illini (Piatt County) -----	72	1	96	2	0	2	0	0	0
		2	9	0	0	0	88	0	3
		3	12	77	5	5	3	6	0
Mixed (Sangamon County) -----	88	1	81	5	1	9	2	0	3
		2	10	7	0	4	80	0	3
		3	16	39	9	11	12	6	9
Illini (Champaign County) -----	90	1	90	2	0	4	2	0	0
		2	8	2	0	4	88	0	1
		3	29	40	9	5	3	4	12
Do -----	94	1	87	7	0	5	1	0	0
		2	5	4	0	2	93	0	1
		3	39	28	2	9	15	4	5
Averages -----	86	1	88.5	4.0	.3	5.0	1.3	0	.8
		2	8.0	3.3	0	2.5	87.3	0	2.0
		3	24.9	46.0	6.3	7.5	8.3	5	6.5

¹ The seeds were surface-sterilized for 30 minutes in an 8-percent BK solution and then plated on potato dextrose agar and incubated for 4 days at about 75° F.; 100 seeds of each class were tested from each of the 4 samples.

² Class 1, healthy appearing seeds; class 2, purple-blotched seeds; class 3, brown-discolored seeds.

³ A fungus which causes purplish coloration in the agar medium and has delicate, restricted mycelial growth that so far has failed to sporulate in culture.

It will be seen from the averages presented in table 1 that 88.5 percent of the healthy-appearing seeds proved to be free from fungus or bacterial infection. On the other hand, 87.3 percent of the purple-blotched seeds yielded a fungus with delicate, restricted mycelial growth that caused a purplish discoloration in the agar medium. So

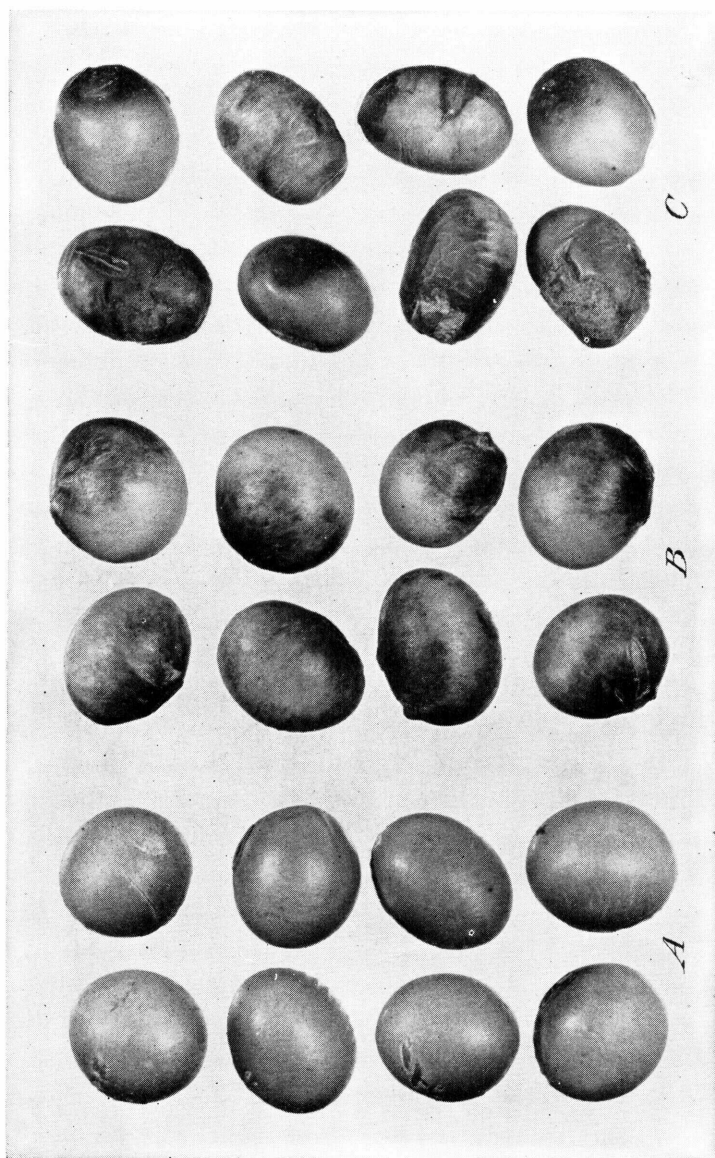


FIGURE 13.—Seeds of the Illini variety of soybeans: *A*, Healthy appearing seeds; *B*, purple-blotched seeds; *C*, seeds with brown discoloration.

far this fungus has failed to sporulate in culture, and it has not been identified, but its cultural appearance and behavior suggest that it is a species of *Cercospora*. Of the seeds showing dull-brown discoloration, 46 percent yielded cultures of *Alternaria*. Although inoculations have not been made to prove the causal relationship of these organisms to the seed discolorations, it is thought that the association shown to exist in a high percentage of the cases is suggestive of such a relationship. Whether or not the *Alternaria* isolated from discolored soybean seeds is able to cause leaf spotting such as was described above is a problem worthy of investigation, but so far no tests to determine this have been made.

The milky-white discoloration of soybean seeds caused by the downy mildew fungus has been discussed (p. 7) and is illustrated in figure 9.

ROOT AND CROWN DISEASES

CHARCOAL ROT

The fungus causing the charcoal rot disease attacks the roots and lower stem and kills the plants prematurely, sometimes before they are half-grown (see title-page illustration). Small black specks, the sclerotia or propagating bodies of the fungus, develop beneath the epidermis of the attacked plants and can be seen only after the outer surface peels off (fig. 14). The disease has been reported on soybeans from 16 counties representing more than two-thirds of southern Illinois and has been observed also in Missouri. Infection may vary from a trace in some fields to as many as 30 or 40 percent diseased plants in others. The causal fungus, *Sclerotium bataticola* Taub., is widely distributed in soils in the warmer sections of the United States and attacks other cultivated plants and some weeds as well as soybeans. Little is known regarding varietal susceptibility and resistance to this disease, and crop rotation is of doubtful value, since the fungus persists for some time in the soil and is able to attack a wide variety of cultivated and wild plants.

SCLEROTIAL BLIGHT

Sclerotial blight, caused by the fungus *Sclerotium rolfsii* Sacc., is also characterized by a rot at the base of the plant stem but differs from charcoal rot in that the fungus sclerotia formed are larger and rounder and are brown instead of black. The entire plant dies, as in the case of charcoal rot. Sclerotial blight is found in the sandy soils of the South where high temperatures occur, and the common name "southern blight" is sometimes applied to this disease. In some areas losses may be as high as 25 to 30 percent of the crop. This fungus also attacks a wide variety of plants, including practically all the summer legumes adapted to the areas where the disease occurs in most severe form, thus making extremely difficult the planning of a soil-improving rotation. Little is known about varietal susceptibility and resistance to the sclerotial blight disease.

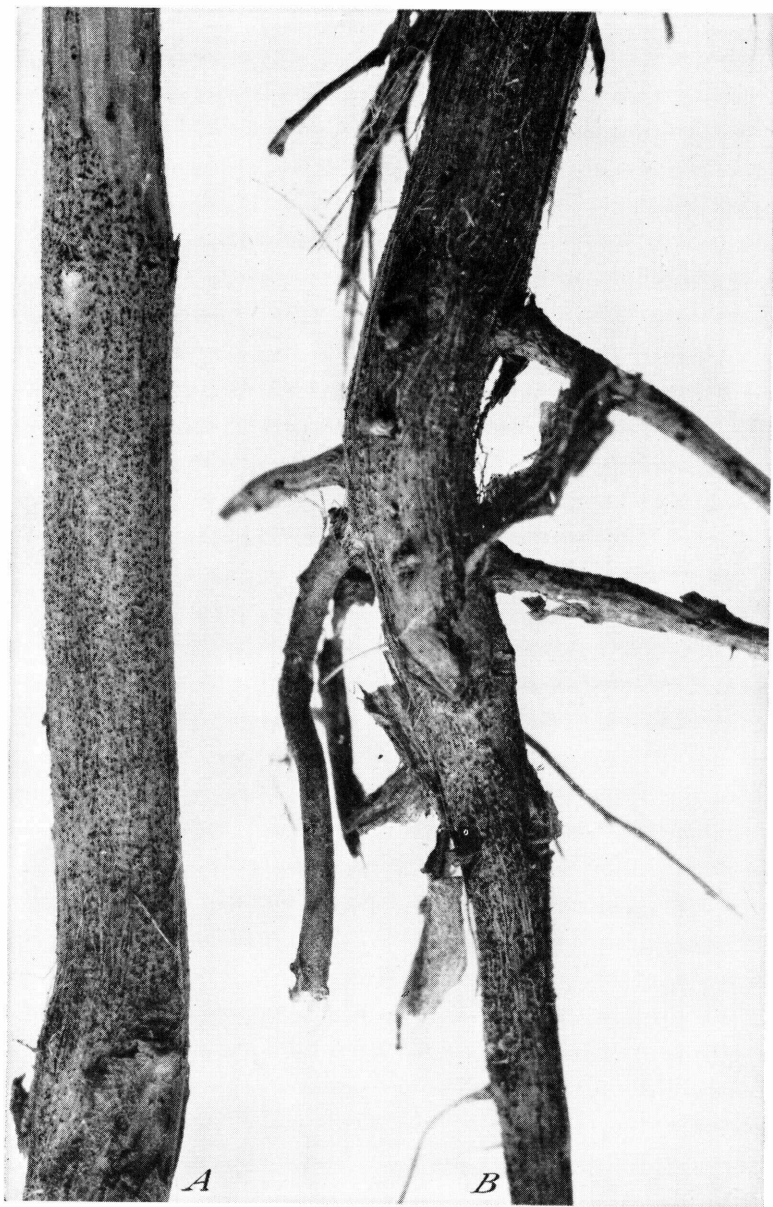


FIGURE 14.—*A*, Enlarged view of the lower stem; *B*, root of a soybean plant killed by charcoal rot, showing numerous small, black sclerotia of the causal fungus after the outer surface had peeled off.

STEM ROT

Another disease that attacks the stem of the plant near the soil level is stem rot, caused by the fungus *Sclerotinia sclerotiorum* (Lib.) DBy. The stem is girdled at the point of attack, and the plant dies above the girdle. The causal fungus forms large, black sclerotia on and within the attacked stems, and these serve to differentiate this disease from charcoal rot, sclerotial blight, and stem blight, all of which kill the plants in a similar manner. Stem rot has been observed to kill soybean plants in New York State, but is thought to be only a minor disease of this crop in the major producing areas.

FUSARIUM BLIGHT

Fusarium blight is characterized by chlorosis and shedding of the leaves, followed by the death of the attacked plants. If the root and stem are split longitudinally, a brown or black discoloration is evident, as in the case of other diseases of this type caused by species of *Fusarium*. Since wilting is not a prominent symptom of this disease on soybeans, the common name "blight" has been suggested, although the causal fungus, *Fusarium oxysporum* f. *tracheiphilum* (E.F.S.) Snyder and Hansen, has been reported by the North Carolina Agricultural Experiment Station to be culturally and morphologically indistinguishable from the organism causing cowpea wilt. Like cowpea wilt, soybean blight is most abundant on coarse, sandy soils. It has been observed in several localities in North Carolina on soils infested with the cowpea wilt fungus and has been reported also from Louisiana and Alabama. More recently a fusarium root rot has been observed on soybeans in Illinois, and it is possible that the causal fungus is the same as that described in the reports from the South.

On infested soil in South Carolina, the Laredo, Palmetto, Monetta, Creole, Charlee, and Clemson varieties of soybeans appeared resistant to blight. In susceptibility studies reported by the North Carolina Agricultural Experiment Station, the Black Eyebrow variety showed resistance, and the Mammoth Brown and Haberlandt varieties showed a high degree of tolerance and matured a fair crop of seed.

PYTHIUM ROOT ROT

Pythium root rot disease is characterized by the development of a wet-rot condition that involves the stem and roots of the plant near the soil level. The rotted portions disintegrate, and the plants wither and die. The disease was reported from North Carolina in 1926 and from Iowa in 1942. Little further is known about the distribution of this root rot. The causal fungus was identified by workers at the North Carolina Agricultural Experiment Station as *Pythium debaryanum* Hesse. Because this fungus is widely distributed and attacks a number of other plants, it may be expected that, under suitable conditions, soybeans will be attacked in other localities.

RHIZOCTONIA AND PHYMATOTRICHUM ROOT ROTS

Several different fungi in addition to those discussed above cause rotting of the roots and the stem of plants near or below the soil line, and two of these are known to attack soybeans. A field of Rokusun

soybeans in which almost half the plants were dying prematurely was reported from Maryland in 1939. The crowns of plants from this field became overgrown with mycelium and sclerotia of *Rhizoctonia solani* Kuehn when placed in a moist chamber, and it appeared that this fungus was responsible for the condition observed in the field.



FIGURE 15.—Nematode root knot on a soybean plant grown at Monetta, S. C.

Rhizoctonia root rot of soybeans was reported as prevalent and destructive in Iowa in 1942. This fungus is widely distributed and attacks a large variety of plants. It appears that under certain conditions it may cause appreciable losses in soybean plantings. The cotton root rot fungus, *Phymatotrichum omnivorum* (Shear) Dug., has been reported to attack soybeans in Texas. Plants attacked by this root rot appear wilted, then die rapidly. When the roots are pulled from the soil the bark is found to be decayed, and frequently brownish, woolly strands of the fungus may be seen on the roots. Rotation with immune plants belonging to the grass family, such as corn, wheat, oats, and sorghum, is recommended to lessen the losses caused by this root rot.

ROOT KNOT

Plants affected with root knot lack vigor and are stunted and pale in color, and death may result from severe attacks. When such plants are dug, irregular swellings or galls are found over the entire root system, as shown in figure 15. The root knot galls are different from the nodules of the beneficial nitrogen-fixing bacteria; nodules are attached loosely to the roots, whereas root knot galls are enlargements of the roots themselves. These swellings of the roots are caused by a microscopic-sized threadworm called the root knot nematode, *Heterodera marioni* (Cornu) Goodey, that bores its way into the roots and so irritates the tissues that galls are produced. Root knot often causes severe injury to soybeans in many parts of the Southern States where this pest is prevalent. Soybean varieties vary markedly in resistance to root knot. The Laredo variety has thus far shown the greatest resistance. The most effective method of controlling root knot combines the use of resistant varieties with other known immune crops in a rotation. Susceptible varieties of soybeans or other crops should not be planted on infested land until it has been planted to immune crops for 2 or 3 years to starve out most of the nematodes.

LIGHTNING INJURY

Observations have been made that suggest that soybeans are probably more subject to lightning injury than many other crops. On



FIGURE 16.—Spot in which young soybean plants were killed by lightning in a field near Urbana, Ill.

the morning after a severe electrical storm near Urbana, Ill., three spots of killed plants ranging from 40 to 50 feet in diameter were observed in fields of young soybeans located not more than a quarter of a mile apart. One such spot is illustrated in figure 16. The lightning made nearly a complete kill of the young soybean plants in the spots, but some weeds in the spots appeared to be injured much less severely. In other cases lightning injury to soybeans has been observed when the plants were practically full-grown and in the blooming stage or after pods had formed. In these cases the area of killed plants was only about 15 feet in diameter but surrounding it was a wide border of plants with blackened stems and blighted leaves. Attention is called to the susceptibility of soybeans to lightning injury, since such spots of dead and blackened plants in soybean fields might easily be mistaken for the result of attack by some root-rotting parasitic disease.

CONTROL MEASURES

Although some suggestions for controlling soybean diseases have been presented as the individual diseases were considered, present knowledge of control measures is discussed in more detail in the following paragraphs for the convenience of the reader.

DISEASE-RESISTANT VARIETIES

Soybean varieties differ markedly in their relative susceptibility and resistance to some of the diseases that attack them. It is possible, therefore, even with the limited information available today, to recommend in some cases that a grower change varieties in order to avoid severe losses from disease. (See Bacterial Pustule, p. 2; Frog-Eye Disease, p. 5; Brown Spot, p. 7; Mosaic, p. 12; Fusarium Blight, p. 19; Root Knot, p. 21.) However, much additional information on susceptibility and resistance to diseases is needed, not only for the older soybean varieties but also for the varieties more recently distributed to the growers in various States. The problem is complicated further by the fact that a variety that is resistant to one disease may be very susceptible to another disease. It appears, therefore, that attempts should be made to develop, either by selection within varieties or by hybridization, new varieties of soybeans that will possess a combination of resistance to several of the more important diseases.

CROP ROTATION

The parasites causing a number of the soybean diseases discussed above are known to overwinter in the fallen, diseased leaves and stems; some of these parasites are known to persist in the soil from year to year. Continuous cropping with susceptible plants therefore would tend to increase the prevalence of these organisms in the soil and thus lead to increasingly severe losses. On the other hand, rotation of soybeans with forage grasses or cereals should tend to keep the losses from diseases at a minimum and therefore should be practiced as a disease-control measure.

The parasites causing several of the diseases discussed in this bulletin are known to infect soybean seed and thus spread the diseases into new fields and new localities. The bacterial diseases, mosaic, pod and stem blight, frog-eye, and downy mildew, are examples of diseases of this type. Seed for planting the following season therefore should not be harvested from the fields in which any of these diseases are prevalent and destructive.

SEED TREATMENT

The results of tests to determine the value of seed treatment with chemical disinfectants in controlling seed-borne diseases of soybeans were reported by the North Carolina Agricultural Experiment Station in 1925 and 1926 and by the Delaware Agricultural Experiment Station in 1929. In North Carolina in 1925 the application of formalin solution, corrosive sublimate solution, and Bayer dust to 2-year-old Mammoth Yellow soybean seed caused no appreciable reduction in the amount of bacterial leaf spot and downy mildew on the resulting plants. Formalin greatly reduced the stand of plants from these 2-year-old seeds, whereas corrosive sublimate and Bayer dust greatly increased the stand as compared with that from untreated seed. These effects on germination were observed again in North Carolina in 1926 with the Mammoth Yellow variety. In all the concentrations used, formaldehyde reduced the germination of the seed very materially, whereas solutions of Semesan and Uspulun, as well as Bayer and Semesan dusts, increased the percentage of germination. It was concluded from these 2 years' results that formaldehyde should not be used as a disinfecting agent for soybean seeds and that the gain in germination due to the use of organic mercury disinfectants may be sufficient to make soybean seed treatment profitable entirely apart from any benefit accruing from control of seed-borne diseases. In the experiment reported from Delaware in 1929, five dust treatments and five wet treatments with a mercury disinfectant proved negative in the control of foliage diseases that are seed-borne.

In 1942 the Oklahoma Agricultural Experiment Station reported that treating seed of Virginia soybeans with Spergon and New Improved Ceresan was effective in preventing seed rots and pre-emergence damping-off when the seed was sown in soil naturally infested with *Rhizoctonia solani*. Differences between the Spergon and Ceresan treatments were not significant.

Greenhouse tests were conducted at the Illinois Agricultural Experiment Station in 1940 with 23 samples of soybean seed, and Semesan Jr. and Cuproside as disinfectants, and in 1942 with 13 seed samples, and Barbak C and Spergon as the disinfectants. The seeds were planted in clean river sand. Emergence of the different untreated samples ranged from 9 to 97 percent. Cuproside failed to benefit emergence, but the other disinfectants caused a significant average increase in stand of 12 percent. Tests on effect of seed treatment on nodulation were also made, using both sterile soil and sand. Treatments were made with Ceresan, Spergon, Semesan Jr., and Cuproside

at the rates of $\frac{3}{4}$, 1, 2, and 5 ounces per bushel, respectively. The seed treatments with fungicide were made first, and these were followed by a standard wet inoculation made 1 hour in advance of planting. Ceresan and Semesan Jr. inhibited nodule formation on the taproot, but there was good nodulation on the lateral roots. Spergon behaved similarly except that it did not entirely prevent taproot nodulation. In appearance, the plants from treated seed, except those treated with Cuproside, were as efficient in nitrogen fixation as the untreated and much better than the uninoculated.

Summarizing, it appears that suitable seed treatment will frequently improve the stand of soybeans, especially when the vitality of the seed is not very high. The use of certain disinfectants seems to be no deterrent to successful inoculation of the seed and subsequent nodulation.

EXCLUSION

Although numerous soybean diseases are known to occur in both the Orient and the United States, there are others that are known to be prevalent in the Orient but so far have not been reported as present in the United States. Constant vigilance on seed imports should be maintained to prevent, if possible, the introduction of these diseases into the soybean-growing regions of the United States. Once introduced, these diseases will be here to stay and may cause significant losses over a period of years.

U. S. GOVERNMENT PRINTING OFFICE: 1943

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington, D. C. - Price 10 cents